Dose remapping and summation for head and neck adaptive radiotherapy applications

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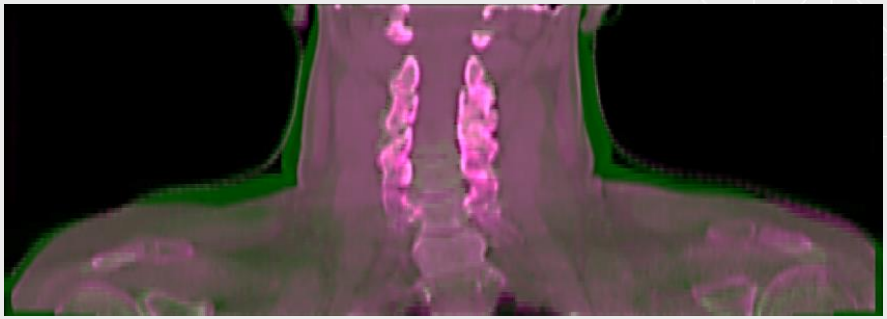
Why adaptive radiotherapy for head and neck patients?

Head and neck patients are a source of concern within UCLH radiotherapy deparment.

- HN is a sensitive cohort
  - Positioning errors
  - Anatomical changes



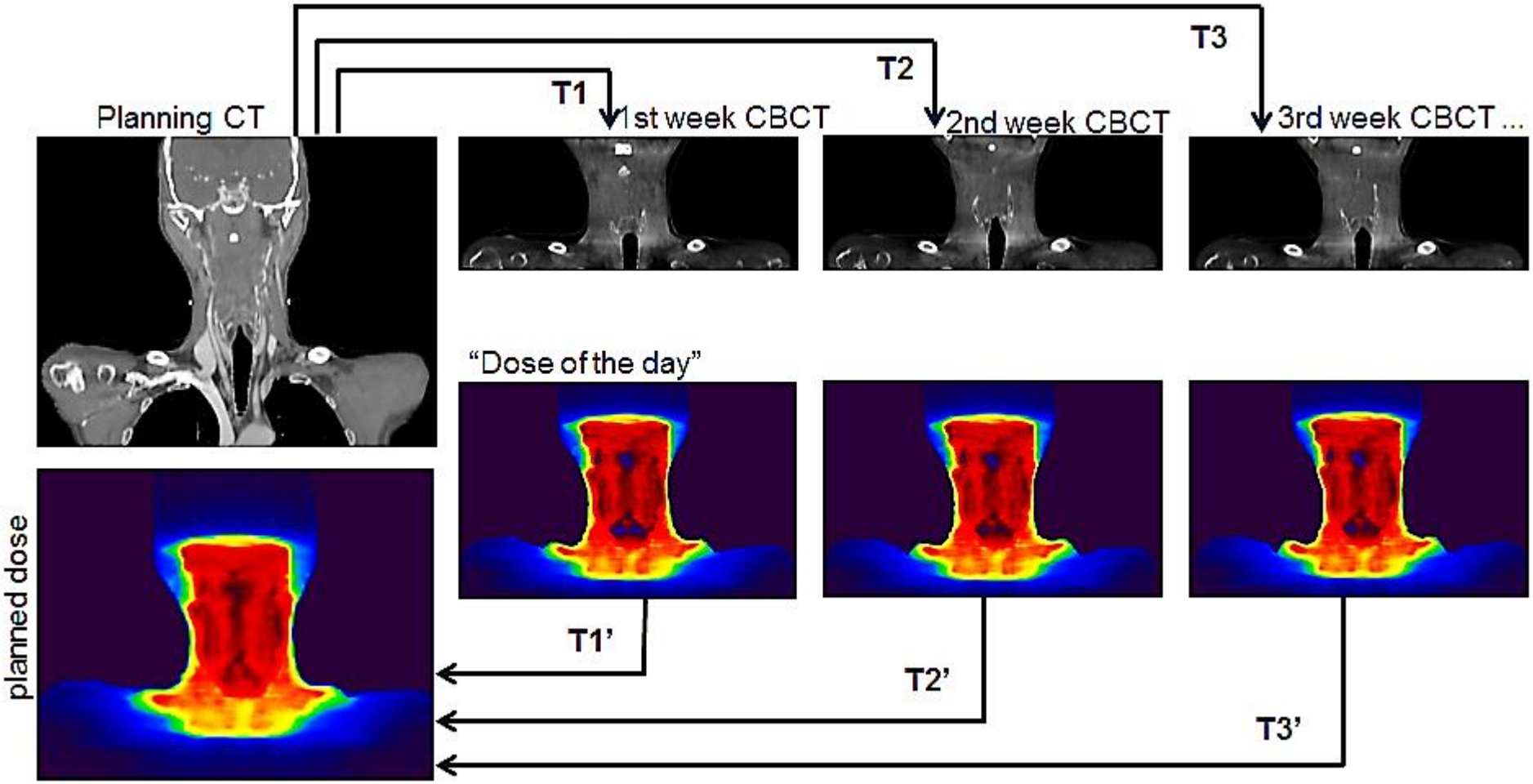
- A set of tight procedures are followed during RT
  - Total of 15 patients re-planned between 2010-2012
  - Reason for re-planning: visible and significant physical changes

Why adaptive radiotherapy for head and neck patients?

- Replanning uses a lot of clinical resources
  - Method to evaluate the necessity and timing of intervention
- In-house validated Deformable Registration for research purposes using CT and CBCT
- Future proton center expecting to treat its first patients in 2018
  - HN one of the cohorts expected to be treated
  - In-room imaging

Artist's impression of how the UCLH Proton Beam Therapy Centre will look. Picture courtesy of Scott Tallon Walker. (http://www.stwarchitects.com/sketchbook.php#item62)

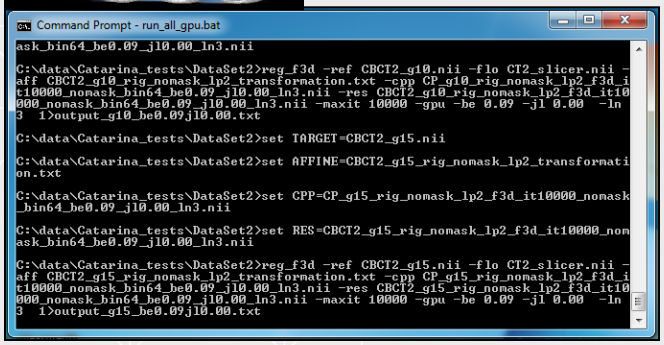
CT-CBT deformable registration for an ART workflow



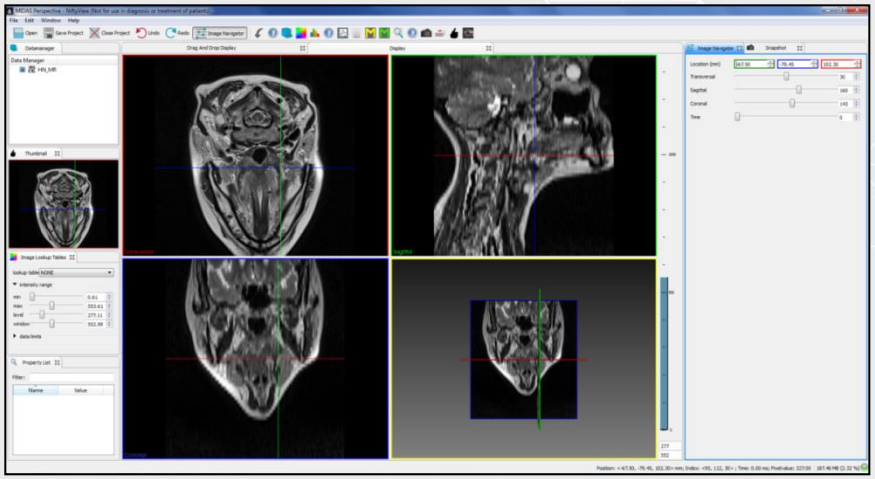
Deformable registration software, NiftyReg

- Software developed by the Centre of Medical Image Computing (CMIC)
- Contains several tools for image registration and visualization

NiftyReg



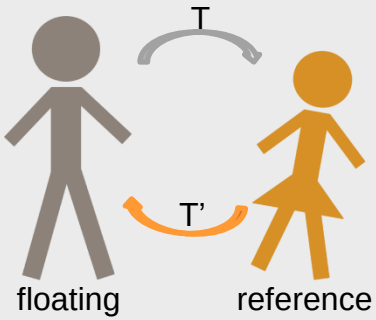
NiftyView



Deformable registration

Free-Form Deformation (FFD) based on B-Splines and voxel-based similarity measure (NMI) GPU implementation

- Standard uni-directional
- Numerical estimation of a deformation field
- Symmetric
- Diffeomorphic

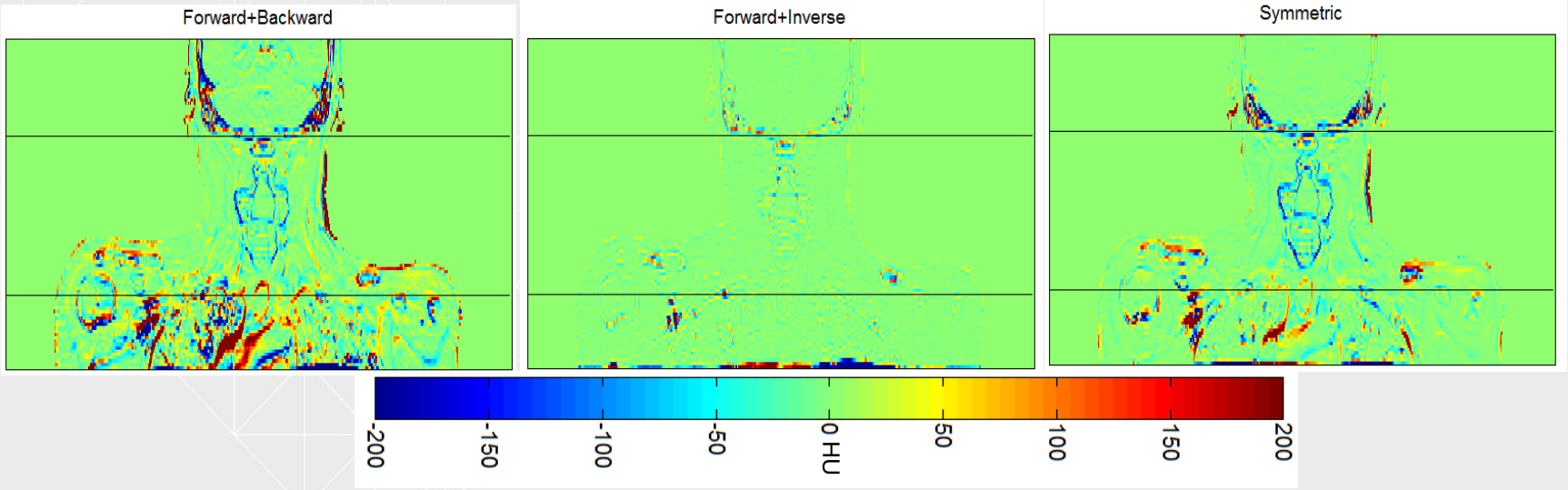


Deformable registration implementations

Advantages	Disavantages
• more realistic and physically plausible deformations • reduced bias towards the direction of the registration	• computationally expensive • point-to-point mapping is hard to validate

dose remapping and dose summation

automatic segmentation and “dose of the day” calculations



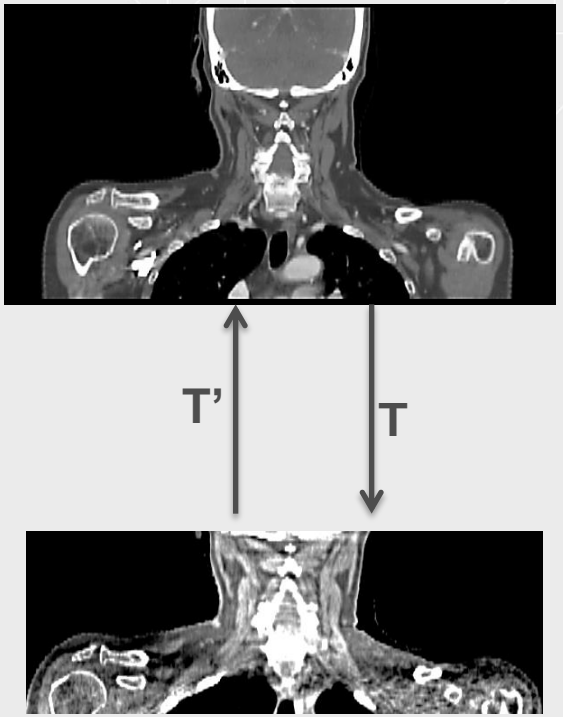
Methods and Materials

Aim: Investigate different implementations of B-Spline DIR for dose remapping and summation applications

- Patient data
  - planning CT and following CBCTs
  - closely monitored due to visible weight loss.
  - IMRT plans

- Dose calculations were performed on a deformed pCT, and mapped back for dose summation using 3 different methods:
  i. Forward+Backward
  ii. Forward+Inverse
  iii. Symmetric

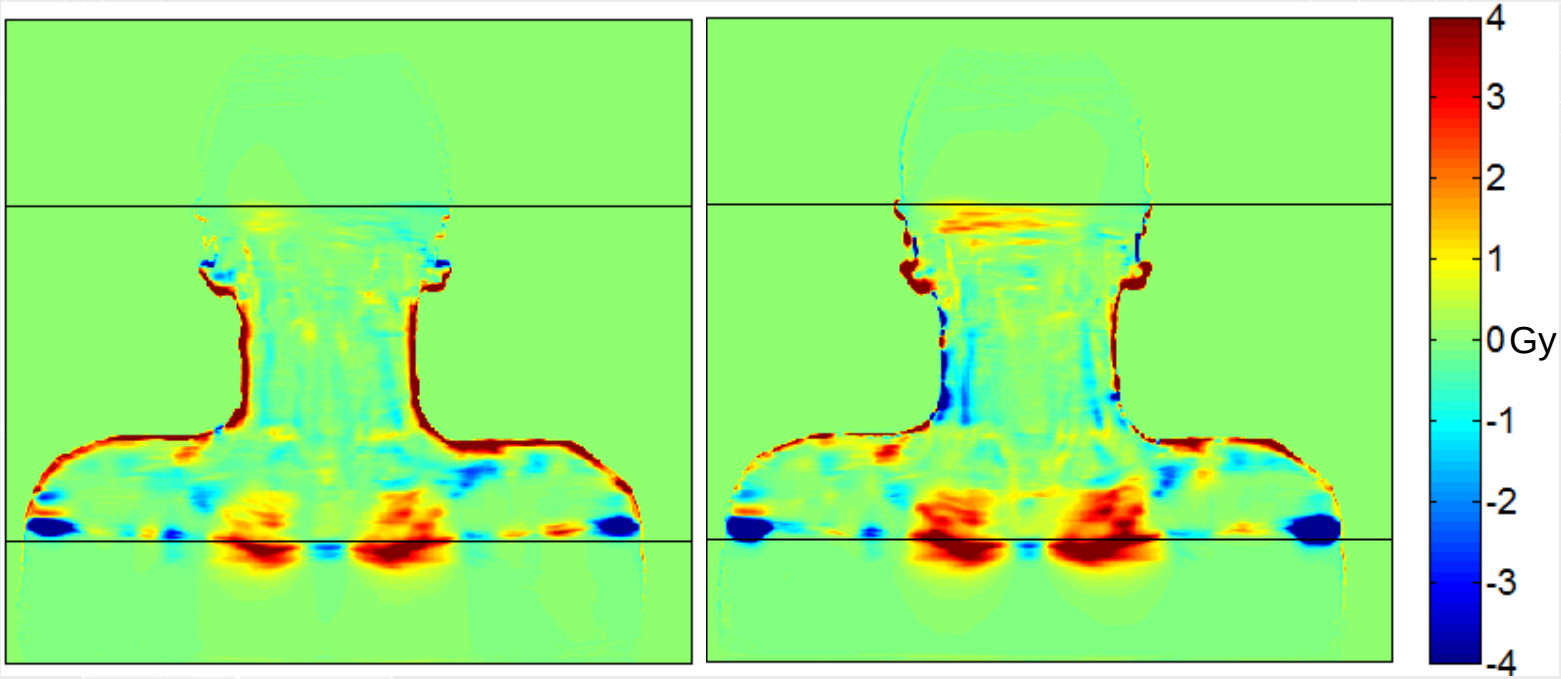
- Cumulative dose distributions displayed on the planning CT space.



Results

Forward+Inverse vs	Forward+ Backward	Symmetric
Dose Differences (<3%pD)	97.0%	96.4%
Gamma analysis (3%/3mm)	99.6%	99.5%

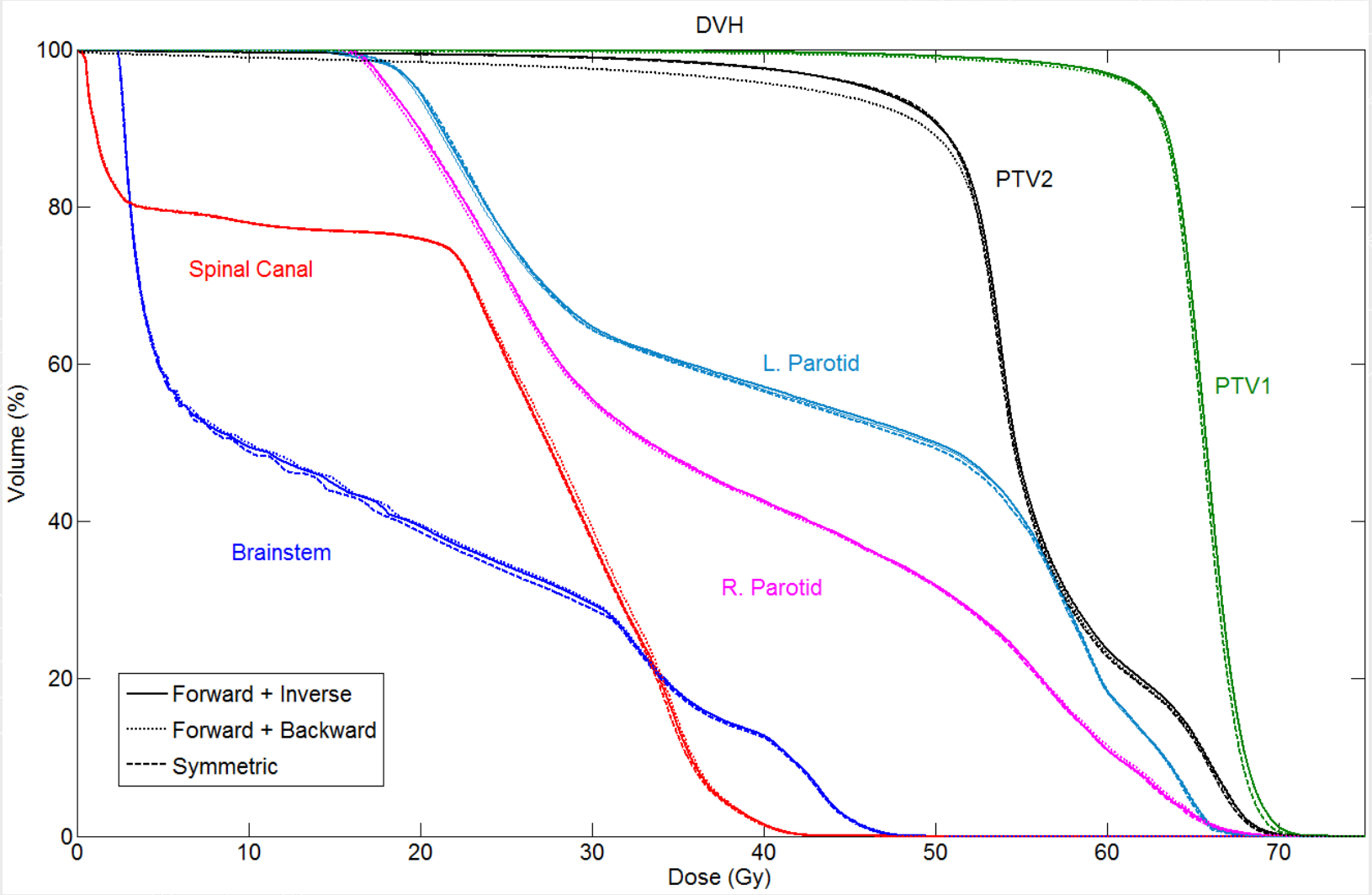
	Forward+ Inverse vs	Forward+ Backward	Symmetric
Max(DD)	Brainstem	0.1 Gy	0.3 Gy
	Spinal Canal	0.8 Gy	0.8 Gy



Forward+Inverse vs Forward+Backward

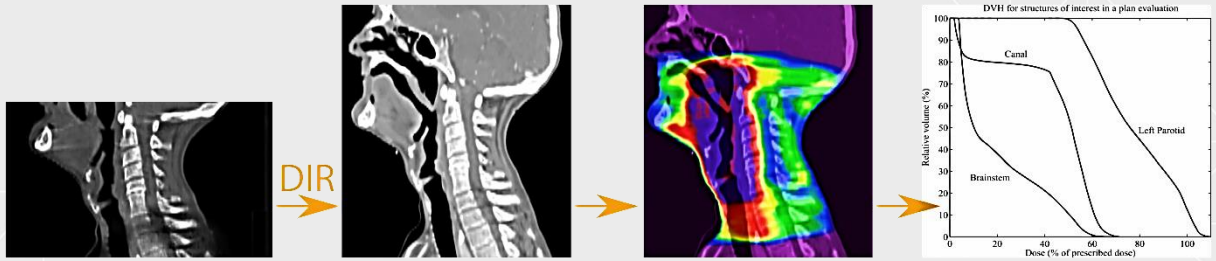
Forward+Inverse vs Symmetric

Results



Discussion and conclusions

- Current state of the work



  - Optimized and validated different implementations of B-Spline registrations
  - Framework for dose remapping and summation.

- Preliminary results on a limited dataset
  - IMRT cumulative dose distributions were overall similar for all methods.
  - Forward+Inverse currently computationally the more efficient.

- Future directions
  - Larger patient cohort
  - Proton therapy applications
  - CBCT in proton therapy – where actually are we?

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